Appendix B
Supplemental Problems

There are no supplemental problems for Chapter 1.

Chapter 2

1. Express the following numbers in scientific notation.
- **a.** 810 000 g
- **b.** 0.000634 g
- **c.** 60 000 000 g
- **d.** 0.0000010 g

2. Convert each of the following time measurements to its equivalent in seconds.
- **a.** 58 ns
- **b.** 0.046 Gs
- **c.** 9270 ms
- **d.** 12.3 ks

3. Solve the following problems. Express your answers in scientific notation.
- **a.** 6.2×10^{-4} m + 5.7×10^{-3} m
- **b.** 8.7×10^{8} km − 3.4×10^{7} km
- **c.** $(9.21 \times 10^{-5}$ cm) $(1.83 \times 10^{8}$ cm)
- **d.** $(2.63 \times 10^{-6}$ m) ÷ $(4.08 \times 10^{6}$ s)

4. State the number of significant digits in the following measurements.
- **a.** 3218 kg
- **b.** 60.080 kg
- **c.** 801 kg
- **d.** 0.000534 kg

5. State the number of significant digits in the following measurements.
- **a.** 5.60×10^{8} m
- **b.** 3.0005×10^{-6} m
- **c.** 8.0×10^{10} m
- **d.** 9.204×10^{-3} m

6. Add or subtract as indicated and state the answer with the correct number of significant digits.
- **a.** 85.26 g + 4.7 g
- **b.** 1.07 km + 0.608 km
- **c.** 186.4 kg − 57.83 kg
- **d.** 60.08 s − 12.2 s

7. Multiply or divide as indicated using significant digits correctly.
- **a.** $(5 \times 10^{8}$ m) $(4.2 \times 10^{7}$ m)
- **b.** $(1.67 \times 10^{-2}$ km) $(8.5 \times 10^{-6}$ km)
- **c.** $(2.6 \times 10^{4}$ kg) ÷ $(9.4 \times 10^{3}$ m^3)
- **d.** $(6.3 \times 10^{-1}$ m) ÷ $(3.8 \times 10^{2}$ s)

8. A rectangular room is 8.7 m by 2.41 m.
- **a.** What length of baseboard molding must be purchased to go around the perimeter of the floor?
- **b.** What area must be covered if floor tiles are laid?

9. The following data table was established showing the total distances an object fell during various lengths of time.

Time (s)	Distance (m)
1.0	5
2.0	20
3.0	44
4.0	78
5.0	123

- **a.** Plot distance vs time from the values given in the table and draw a curve that best fits all points.
- **b.** Describe the resulting curve.
- **c.** According to the graph, what is the relationship between distance and time for a free-falling object?

10. The total distance a lab cart travels during specified lengths of time is given in the following table.

Time (s)	Distance (m)
1.0	0.32
2.0	0.60
3.0	0.95
4.0	1.18
5.0	1.45

- **a.** Plot distance vs time from the values given in the table and draw the curve that best fits all points.
- **b.** Describe the resulting curve.
- **c.** According to the graph, what type of relationship exists between the total distance traveled by the lab cart and the time?
- **d.** What is the slope of this graph?
- **e.** Write an equation relating distance and time for this data.

11. Solve the equation

$$F = \frac{mv^2}{r}$$

a. for m. **b.** for r. **c.** for v.

12. Solve the equation for d_o.

$$\frac{1}{f} = \frac{1}{d_o} + \frac{1}{d_i}$$

13. A cube has an edge of length 5.2 cm.
- **a.** Find its surface area.
- **b.** Find its volume.

14. A truck is traveling at a constant velocity of 70 km/h. Convert the velocity to m/s.

15. The density of gold is 19.3 g/cm^3. A gold washer has an outside radius of 4.3 cm and an inside radius of 2.1 cm. Its thickness is 0.14 cm. What is the mass of the washer?

Chapter 3

1. Bob walks 80 m and then he walks 125 m.
- **a.** What is Bob's displacement if he walks east both times?
- **b.** What is Bob's displacement if he walks east then west?
- **c.** What distance does Bob walk in each case?

2. A cross-country runner runs 5.0 km east along the course, then turns around and runs 5.0 km west along the same path. She returns to the starting point in 40 min. What is her average speed? her average velocity?

3. 0.30 s after seeing a puff of smoke rise from the starter's pistol, the sound of the firing of the pistol is heard by the track timer 100 m away. What is the velocity of sound?

4. The radius of the tires on a particular vehicle is 0.62 m. If the tires are rotating 5 times per second, what is the velocity of the vehicle?

5. A bullet is fired with a speed of 720.0 m/s.
- **a.** What time is required for the bullet to strike a target 324 m away?
- **b.** What is the velocity in km/h?

6. Light travels at 3.0×10^{8} m/s. How many seconds go by from the moment the starter's pistol is shot until the smoke is seen by the track timer 100 m away?

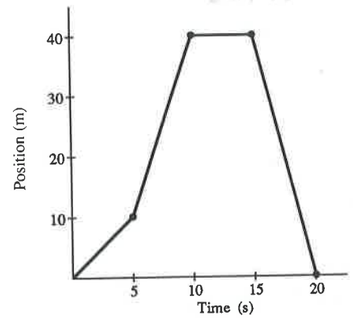
7. You drive your car from home at an average velocity of 80 km/h for 3 h. Halfway to your destination, you develop some engine problems, and for 5 h you nurse the car the rest of the way. What is your average velocity for the entire trip?

8. The total distance a ball is off the ground when thrown vertically is given for each second of flight by the following table.

Time (s)	Distance (m)
0.0	0.0
1.0	24.5
2.0	39.2
3.0	44.1
4.0	39.2
5.0	24.5
6.0	0.0

- **a.** Draw a position-time graph of the motion of the ball.
- **b.** How far off the ground is the ball at the end of 0.5 s? When would the ball again be this distance from the ground?

9. Use the following position-time graph to find how far the object travels between
- **a.** t = 0 s and t = 5 s.
- **b.** t = 5 s and t = 10 s.
- **c.** t = 10 s and t = 15 s.
- **d.** t = 15 s and t = 20 s.
- **e.** t = 0 s and t = 20 s.



10. Use the position-time graph from problem 9 to find the object's velocity between
- **a.** t = 0 s and t = 5 s.
- **b.** t = 5 s and t = 10 s.
- **c.** t = 10 s and t = 15 s.
- **d.** t = 15 s and t = 20 s.

11. Two cars are headed in the same direction; one travelling 60 km/h is 20 km ahead of the other travelling 80 km/h.
- **a.** Draw a position-time graph showing the motion of the cars.
- **b.** Use your graph to find the time when the faster car overtakes the slower one.

12. Use your graph from Problem 8 to calculate the ball's instantaneous velocity at
a. t = 2 s. **b.** t = 3 s. **c.** t = 4 s.

13. A plane flies in a straight line at a constant velocity of +75 m/s. Assume that it is at the reference point when the clock reads $t = 0$.
- **a.** Construct a table showing the position or displacement of the plane at the end of each second for a 10-s period.
- **b.** Use the data from the table to plot a position-time graph.
- **c.** Show that the slope of the line is the velocity of the plane. Use at least two different sets of points along the line.
- **d.** Plot a velocity-time graph of the plane's motion for the first 6 s of the 10-s interval.
- **e.** From the velocity-time graph, find the displacement of the plane between the second and the sixth period.

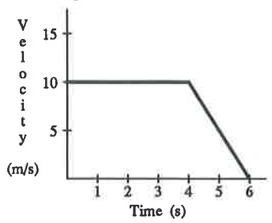
14. Mary jogs for 15 min at 240 m/min, walks the next 10 min at 90 m/min, rests for 5 min, and jogs back to where she started at −180 m/min.
- **a.** Plot a velocity-time graph for Mary's exercise run.
- **b.** Find the area under the curve for the first 15 min. What does this represent?
- **c.** What is the total distance travelled by Mary?
- **d.** What is Mary's displacement from start to finish?

15. Car A is travelling at 85 km/h while car B is at 60 km/h. What is the relative velocity of car A to car B
- **a.** if they both are travelling in the same direction?
- **b.** if they are headed towards each other?

Chapter 4

1. From the moment a 40 m/s fastball touches the catcher's mitt until it is completely stopped takes 0.012 s. Calculate the average acceleration of the ball as it is being caught.

2. The following velocity-time graph describes a familiar motion of a car traveling during rush-hour traffic.
- **a.** Describe the car's motion from $t = 0$ s to $t = 4$ s.
- **b.** Describe the car's motion from $t = 4$ s to $t = 6$ s.
- **c.** What is the average acceleration for the first 4 s?
- **d.** What is the average acceleration from $t = 4$ s to $t = 6$ s?



3. Given the following table:

Time (s)	Velocity (m/s)
0.0	0.0
1.0	5.0
2.0	20.0
3.0	45.0
4.0	80.0

- **a.** Plot a velocity-time graph for this motion.
- **b.** Is this motion constant velocity? uniform acceleration?
- **c.** Calculate the instantaneous acceleration at $t = 3.0$ s.

4. Top-fuel drag racers are able to uniformly accelerate at 12.5 m/s^2 from rest to 100 m/s before crossing the finish line. How much time elapses during the run?

5. A race car accelerates from rest at +7.5 m/s^2 for 4.5 s. How fast will it be going at the end of that time?

6. A race car starts from rest and is accelerated uniformly to +41 m/s in 8.0 s. What is the car's displacement?

7. A jet plane travelling at +88 m/s lands on a runway and comes to rest in 11 s.
- **a.** Calculate its uniform acceleration.
- **b.** Calculate the displacement it travels.

8. A bullet accelerates at 6.8×10^4 m/s^2 from rest as it travels the 0.80 m of the rifle barrel.
- **a.** How long was the bullet in the barrel?
- **b.** What velocity does the bullet have as it leaves the barrel?

9. A car travelling at 14 m/s encounters a patch of ice and takes 5.0 s to stop.
- **a.** What is the car's acceleration?
- **b.** How far does it travel before stopping?

10. A motorcycle travelling at 16 m/s accelerates at a constant rate of 4.0 m/s^2 over 50 m. What is its final velocity?

11. A hockey player skating at 18 m/s comes to a complete stop in 2.0 m. What is the acceleration of the hockey player?

12. Police find skid marks 60 m long on a highway showing where a car made an emergency stop. Assuming that the acceleration was −10 m/s^2 (about the maximum for dry pavement), how fast was the car going? Was the car exceeding the 80 km/h speed limit?

13. An accelerating lab cart passes through two photo gate timers 3.0 m apart in 4.2 s. The velocity of the cart at the second timer is 1.2 m/s.
- **a.** What is the cart's velocity at the first gate?
- **b.** What is the acceleration?

14. A camera is accidentally dropped from the edge of a cliff and 6.0 s later hits the bottom.
- **a.** How fast was it going just before it hit?
- **b.** How high is the cliff?

15. A rock is thrown vertically with a velocity of 20 m/s from the edge of a bridge 42 m above a river. How long does the rock stay in the air?

16. A platform diver jumps vertically with a velocity of 4.2 m/s. The diver enters the water 2.5 s later. How high is the platform above the water?

Chapter 5

1. A towrope is used to pull a 1750-kg car, giving it an acceleration of 1.35 m/s^2. What force does the rope exert?

2. A racing car undergoes a uniform acceleration of 4.00 m/s^2. If the net force causing the acceleration is 3.00×10^3 N, what is the mass of the car?

3. A 5.2-kg bowling ball is accelerated from rest to a velocity of 12 m/s as the bowler covers 5.0 m of approach before releasing the ball. What force is exerted on the ball during this time?

4. A high jumper, falling at 4.0 m/s, lands on a foam pit and comes to rest, compressing the pit 0.40 m. If the pit is able to exert an average force of 1200 N on the high jumper in breaking the fall, what is the jumper's mass?

5. When a 20-kg child steps off a 3.0-kg stationary skateboard with an acceleration of 0.50 m/s^2, with what acceleration will the skateboard travel in the opposite direction?

6. On Planet X, a 50-kg barbell can be lifted by only exerting a force of 180 N.
- **a.** What is the acceleration of gravity on Planet X?
- **b.** If the same barbell is lifted on Earth, what minimal force is needed?

7. A proton has a mass of 1.672×10^{-27} kg. What is its weight?

8. A force of 20 N accelerates a 9.0-kg wagon at 2.0 m/s^2 along the sidewalk.
- **a.** How large is the frictional force?
- **b.** What is the coefficient of friction?

9. A 2.0-kg brick has a sliding coefficient of friction of 0.38. What force must be applied to the brick for it to move at a constant velocity?

10. In bench pressing 100 kg, a weight lifter applies a force of 1040 N. How large is the upward acceleration of the weights during the lift?

11. An elevator that weighs 3.0×10^3 N is accelerated upward at 1.0 m/s^2. What force does the cable exert to give it this acceleration?

12. A person weighing 490 N stands on a scale in an elevator.
- **a.** What does the scale read when the elevator is at rest?
- **b.** What is the reading on the scale when the elevator rises at a constant velocity?
- **c.** The elevator slows down at −2.2 m/s^2 as it reaches the desired floor. What does the scale read?
- **d.** The elevator descends, accelerating at −2.7 m/s^2. What does the scale read?
- **e.** What does the scale read when the elevator descends at a constant velocity?
- **f.** Suppose the cable snapped and the elevator fell freely. What would the scale read?

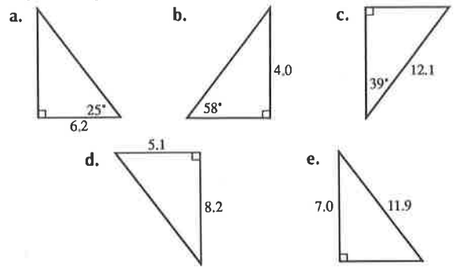
13. A 10.0-kg mass, m_1, on a frictionless table is accelerated by a 5.0-kg mass, m_2, hanging over the edge of the table. What is the acceleration of the mass along the table?

Chapter 6

1. Find θ if
- **a.** $\tan \theta = 9.5143$.
- **b.** $\sin \theta = .4540$.
- **c.** $\cos \theta = .8192$.
- **d.** $\tan \theta = .1405$.
- **e.** $\sin \theta = .7547$.
- **f.** $\cos \theta = .9781$.

2. Find the value of:
- **a.** tan 28°.
- **b.** sin 86°.
- **c.** cos 2°.
- **d.** tan 58°.
- **e.** sin 40°.
- **f.** cos 71°.

3. Solve for all sides and all angles for the following right triangles.



4. An 80-N and a 60-N force act concurrently on a point. Find the magnitude of the vector sum if the forces pull
a. in the same direction.
b. in opposite directions.
c. at a right angle to each other.

5. You head downstream on a river in an outboard. The current is flowing at a rate of 1.50 m/s. After 30.0 min, you find that you have traveled 24.3 km. How long will it take you to travel back upstream to your original point of departure?

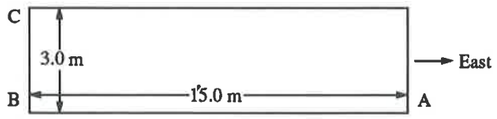
6. One force of 60 N and a second of 30 N act on an object at point **P**. Graphically add the vectors and find the magnitude of the resultant when the angle between them is as follows.
a. 0° **b.** 30° **c.** 45° **d.** 60° **e.** 90° **f.** 180°

7. You walk 30 m south and 30 m east. Draw and add vectors representing these two displacements.

8. A plane flying at 90° at 1.00×10^2 m/s is blown toward 180° at 5.0×10^1 m/s by a strong wind. Find the plane's resultant velocity and direction.

9. In tackling a running back from the opposing team, a defensive lineman exerts a force of 500 N at 180°, while a linebacker simultaneously applies a force of 650 N at 270°. What is the resultant force on the ball carrier?

10. A person rides in a freight car 15 m long and 3.0 m wide. The car is moving east at 2.5 m/s. Exploring the surroundings, he walks from corner A to corner B in 20.0 s; then from corner B to corner C in 5.0 s as shown. With the aid of a vector diagram, compute his displacement relative to the ground.



11. A plane travels on a heading of 40.0° for a displacement of 3.00×10^2 km. How far north and how far east does the plane travel?

12. A water skier is towed by a speedboat. The skier moves to one side of the boat in such a way that the tow rope forms an angle of 55° with the direction of the boat. The tension on the rope is 350 N. What would be the tension on the rope if the skier were directly behind the boat?

13. What are the *x* and *y* components of a velocity vector of magnitude 100 km/h and direction of 240°?

14. Wendy pushes a lawn spreader across a lawn by applying a force of 95 N along the handle that makes an angle of 60.0° with the horizontal.
a. What are the horizontal and vertical components of the force?
b. The handle is lowered so it makes an angle of 30.0° with the horizontal. Now what are the horizontal and vertical components of the force?

15. A brick layer applies a force of 100 N to each of two handles of a wheelbarrow. Its mass is 20 kg and it is loaded with 30 bricks, each of mass 1.5 kg. The handles of the wheelbarrow are 30° from the horizontal and the coefficient of friction is 0.20. What initial acceleration is given the wheelbarrow?

16. Two 15-N forces act concurrently on point **P**. Find the magnitude of their resultant when the angle between them is
a. 0.0°. **b.** 30.0°. **c.** 90.0°. **d.** 120.0°. **e.** 180.0°.

17. You are a pilot on an aircraft carrier. You must fly to another aircraft carrier, now 1450 km at 45° of your position, moving at 56 km/h due east. The wind is blowing from the south at 72 km/h. Calculate the heading and air speed needed to reach the carrier 2.5 h after you take off. **Hint:** Draw a displacement vector diagram.

18. A 33-N force acting at 90° and a 44-N force acting at 60° act concurrently on point **P**. What is the magnitude and direction of a third force that produces equilibrium at point **P**?

19. A person weighs 612 N. If the person sits in the middle of a hammock that is 3.0 m long and sags 1.0 m below the points of support, what force would be exerted by each of the two hammock ropes?

20. A bell ringer decides to use a bowling ball to ring the bell. He hangs the 7.3-kg ball from the end of a 2.0 m long rope. He attaches another rope to the ball to pull the ball back, and pulls it horizontally until the ball has moved 0.60 m away from the vertical. How much force must he apply?

21. A mass, *M*, starts from rest and slides down the frictionless incline, Figure 6–19. As it leaves the incline, its speed is 24 m/s.
a. What is the acceleration of the mass while on the incline?
b. What is the length of the incline?
c. How long does it take the mass to reach the floor after it leaves the top of the incline?

Chapter 7

1. A ball falls from rest from a height of 490 m.
a. How long does it remain in the air?
b. If the ball has a horizontal velocity of 2.00×10^2 m/s when it begins its fall, what horizontal displacement will it have?

2. An archer stands 40.0 m from the target. If the arrow is shot horizontally with a velocity of 90.0 m/s, how far above the bull's-eye must he aim to compensate for gravity pulling his arrow downward?

3. A bridge is 176.4 m above a river. If a lead-weighted fishing line is thrown from the bridge with a horizontal velocity of 22.0 m/s, how far has it moved horizontally when it hits the water?

4. A beach ball, moving with a speed of +1.27 m/s, rolls off a pier and hits the water 0.75 m from the end of the pier. How high above the water is the pier?

5. Pete has a tendency to drop his bowling ball on his release. Instead of having the ball on the floor at the completion of his swing, Pete lets go with the ball 0.35 m above the floor. If he throws it horizontally with a velocity of 6.3 m/s, what distance does it travel before you hear a "thud"?

6. A discus is released at an angle of 45° and a velocity of 24.0 m/s.
a. How long does it stay in the air?
b. What horizontal displacement does it travel?

7. A shot put is released with a velocity of 12 m/s and stays in the air for 2.0 s.
a. At what angle with the horizontal was it released?
b. What horizontal displacement did it travel?

8. A football is kicked at 45° and travels 82 m before hitting the ground.
a. What was its initial velocity?
b. How long was it in the air?
c. How high did it go?

9. A golf ball is hit with a velocity of 24.5 m/s at 35.0° above the horizontal. Find
a. the range of the ball.
b. the maximum height of the ball.

10. A carnival clown rides a motorcycle down a ramp and around a "loop-the-loop." If the loop has a radius of 18 m, what is the slowest speed the rider can have at the top of the loop to avoid falling? **Hint:** At this slowest speed, at the top of the loop, the clown's weight is equal to the centripetal force.

11. A 75-kg pilot flies a plane in a loop. At the top of the loop, where the plane is completely upside-down for an instant, the pilot hangs freely in the seat and does not push against the seat belt. The airspeed indicator reads 120 m/s. What is the radius of the plane's loop?

12. A 2.0-kg object is attached to a 1.5 m long string and swung in a vertical circle at a constant speed of 12 m/s.
a. What is the tension in the string when the object is at the bottom of its path?
b. What is the tension in the string when the object is at the top of its path?

13. A 60.0-kg speed skater with a velocity of 18.0 m/s comes into a curve of 20.0-m radius. How much friction must be exerted between the skates and ice to negotiate the curve?

14. A 20.0-kg child wishes to balance on a seesaw with a child of 32.0 kg. If the smaller child sits 3.2 m from the pivot, where must the larger child sit?

15. A pendulum has a length of 1.00 m.
a. What is its period on Earth?
b. What is its period on the moon where the acceleration due to gravity is 1.67 m/s^2?

16. The period of an object oscillating on a spring is

$$T = 2\pi\sqrt{\frac{m}{k}},$$

where m is the mass of the object and k is the spring constant which indicates the force necessary to produce a unit elongation of the spring. The period of a simple pendulum is

$$T = 2\pi\sqrt{\frac{l}{|g|}}.$$

a. What mass will produce a 1.0-s period of oscillation if it is attached to a spring with a spring constant of 4.0 N/m?
b. What length pendulum will produce a period of 1.0 s?
c. How would the harmonic oscillator and the pendulum have to be modified in order to produce 1.0-s periods on the surface of the moon where g is 1.6 m/s^2?

Chapter 8

1. Comet Halley returns every 76 years. Find the average distance of the comet from the sun.

2. Area is measured in m^2, so the rate at which area is swept out by a planet or satellite is measured in m^2/s.
a. How fast is area swept out by Earth in its orbit about the sun? See table 8–1.
b. How fast is area swept out by the moon in its orbit about Earth? Use 3.9×10^8 m as the average distance between the Earth and the moon, and 27.3 days as the moon's period.

3. You wish to launch a satellite that will remain above the same spot on Earth's surface. This means the satellite must have a period of exactly one day. Calculate the radius of the circular orbit this satellite must have. **Hint:** The moon also circles Earth and both the moon and the satellite will obey Kepler's third law. The moon is 3.8×10^8 m from Earth and its period is 27.33 days.

4. The mass of an electron is 9.1×10^{-31} kg. The mass of a proton is 1.7×10^{-27} kg. They are about 1.0×10^{-10} m apart in a hydrogen atom. What gravitational force exists between the proton and the electron of a hydrogen atom?

5. Two 1.00-kg masses have their centres 1.00 m apart. What is the force of attraction between them?

6. Two satellites of equal mass are put into orbit 30 m apart. The gravitational force between them is 2.0×10^{-7} N.
a. What is the mass of each satellite?
b. What is the initial acceleration given to each satellite by the gravitational force?

7. Two large spheres are suspended close to each other. Their centres are 4.0 m apart. One sphere weighs 9.8×10^2 N. The other sphere has a weight of 1.96×10^2 N. What is the gravitational force between them?

8. If the centres of Earth and the moon are 3.9×10^8 m apart, the gravitational force between them is about 1.9×10^{20} N. What is the approximate mass of the moon?

9. **a.** What is the gravitational force between two spherical 8.00-kg masses that are 5.0 m apart?
b. What is the gravitational force between them when they are 5.0×10^1 m apart?

10. A satellite is placed in a circular orbit with a radius of 1.0×10^7 m a period of 9.9×10^3 s. Calculate the mass of Earth. **Hint:** Gravity supplies the needed centripetal force for such a satellite. Scientists have actually measured the mass of Earth this way.

11. If you weigh 637 N on Earth's surface, how much would you weigh on the planet Mars? (Mars has a mass of 6.37×10^{23} kg and a radius of 3.43×10^6 m.)

12. Using Newton's variation of Kepler's third law and information from Table 8–1, calculate the period of Earth's moon if the radius of orbit was twice the actual value of 3.9×10^8 m.

13. Use the data from Table 8–1 to find the speed and period of a satellite that would orbit Mars 175 km above its surface.

14. What would be the value of g, acceleration of gravity, if Earth's mass was double its actual value, but its radius remained the same? If the radius was doubled, but the mass remained the same? If both the mass and radius were doubled?

15. What would be the strength of Earth's gravitational field at a point where an 80.0-kg astronaut would experience a 25% reduction in weight?

16. On the surface of the moon, a 91.0-kg physics teacher weighs only 145.6 N. What is the value of the moon's gravitational field at its surface?

Chapter 9

1. Jim strikes a 0.058-kg golf ball with a force of 272 N and gives it a velocity of 62.0 m/s. How long was the club in contact with the ball?

2. A force of 186 N acts on a 7.3-kg bowling ball for 0.40 s.
a. What is the bowling ball's change in momentum?
b. What is its change in velocity?

3. A 5500-kg freight truck accelerates from 4.2 m/s to 7.8 m/s in 15.0 s by applying a constant force.
a. What change in momentum occurs?
b. How large of a force is exerted?

4. In running a ballistics test at the police department, officer Spears fires a 6.0-g bullet at 350 m/s into a container that stops it in 0.30 m. What average force stops the bullet?

5. A 0.24-kg volleyball approaches Jennifer with a velocity of 3.8 m/s. Jennifer bumps the ball giving it a velocity of −2.4 m/s. What average force did she apply if the interaction time between her hands and the ball is 0.025 s?

6. A 0.145-kg baseball is pitched at 42 m/s. The batter hits it horizontally to the pitcher at 58 m/s.
a. Find the change in momentum of the ball.
b. If the ball and bat were in contact 4.6×10^{-4} s, what would be the average force while they touched?

7. A 550-kg car travelling at 24.0 m/s collides head-on with a 680-kg pick-up truck. Both vehicles come to a complete stop upon impact.
a. What is the momentum of the car before collision?
b. What is the change in the car's momentum?
c. What is the change in the truck's momentum?
d. What is the velocity of the truck before collision?

8. A truck weighs four times as much as a car. If the truck coasts into the car at 12 km/h and they stick together, what is their final velocity?

9. A 50.0-g projectile is launched with a horizontal velocity of 647 m/s from a 4.65-kg launcher moving in the same direction at 2.00 m/s. What is the velocity of the launcher after the projectile is launched?

10. Two lab carts are pushed together with a spring mechanism compressed between them. Upon release, the 5.0-kg cart repels one way with a velocity of 0.12 m/s while the 2.0-kg cart goes in the opposite direction. What velocity does it have?

11. A 12.0-g rubber bullet travels at a velocity of 150 m/s, hits a stationary 8.5-kg concrete block resting on a frictionless surface, and ricochets in the opposite direction with a velocity of −100 m/s. How fast will the concrete block be moving?

12. A 6500-kg freight car travelling at 2.5 m/s collides with an 8000-kg stationary freight car. If they interlock upon collision, find their velocity.

13. Tim, mass 42.00 kg, is riding a skateboard, mass 2.00 kg, travelling at 1.20 m/s. Tim jumps off and the skateboard stops dead in its tracks. In what direction and with what velocity did he jump?

14. A cue ball, mass 0.16 kg, rolling at 4.0 m/s, hits a stationary eight-ball of similar mass. If the cue ball travels 45° above its original path, and the eight-ball at 45° below, what is the velocity of each after collision?

15. Two opposing hockey players, one of mass 82.0 kg skating north at 6.0 m/s and the other of mass 70.0 kg skating east at 3.0 m/s, collide and become tangled.
a. Draw a vector momentum diagram of the collision.
b. In what direction and with what velocity do they move after collision?

Chapter 10

1. After scoring a touchdown, an 84.0-kg wide receiver celebrates by leaping 120 cm off the ground. How much work was done in the celebration?

2. During a tug-of-war, Team A does 2.20×10^5 J of work in pulling Team B 8.00 m. What force was Team A exerting?

3. To keep a car travelling at a constant velocity, 551 N of force is needed to overcome frictional forces. How much work is done against friction by the car in travelling a distance of 161 km?

4. A weightlifter raises a 180-kg barbell to a height of 1.95 m. How much work was done by the weightlifter in lifting the barbells?

5. A wagon is pulled by a force of 38.0 N on the handle at an angle of 42° with the horizontal. If the wagon is pulled in a circle of radius 25.0 m, how much work is done?

6. A 185-kg refrigerator is loaded into a moving van by pushing it up a 10.0-m ramp at an angle of inclination of 11°. How much work is done?

7. A lawn mower is pushed with a force of 88.0 N along a handle that makes an angle of 41° with the horizontal. How much work is done in pushing the mower 1.2 km in mowing the yard?

8. A 17.0-kg crate is to be pulled a distance of 20.0 m requiring 1210 J of work being done. If the job is done by attaching a rope and pulling with a force of 75.0 N, at what angle is the rope held?

9. An elevator lifts a total mass of 1.1×10^3 kg, a distance of 40.0 m in 12.5 s. How much power does the elevator demonstrate?

10. A cyclist exerts a force of 15.0 N in riding a bike 251 m in 30.0 s. What is the cyclist's power?

11. A 120-kg lawn tractor goes up a 21° incline of 12.0 m in 2.5 s. What power is shown by the tractor?

12. What power does a pump develop to lift 35 L of water per minute from a depth of 110 m? (A litre of water has a mass of 1.00 kg.)

13. A force of 1.4 N is exerted through a distance of 40.0 cm on a rope in a pulley system to lift a 0.50-kg mass 10.0 cm.
- **a.** Calculate the *MA*.
- **b.** Calculate the *IMA*.
- **c.** What is the efficiency of the pulley system?

14. A student exerts a force of 250 N through a distance of 1.6 m on a lever in lifting a 150-kg crate. If the efficiency of the lever is 90%, how far is the crate lifted?

15. Karen pedals a bicycle with a gear radius of 5.00 cm and a wheel radius of 38.6 cm. What length of chain must be pulled through to make the wheel revolve once?

Chapter 11

1. Calculate the kinetic energy of a proton, mass 1.67×10^{-27} kg, traveling at 5.20×10^7 m/s.

2. What is the kinetic energy of a 3.2-kg pike swimming at 2.7 km/h?

3. A force of 30.0 N pushes a 1.5-kg cart, initially at rest, a distance of 2.8 m along a frictionless surface.
- **a.** Find the work done on the cart.
- **b.** What is its change in kinetic energy?
- **c.** What is the cart's final velocity?

4. A bike and rider, 82.0-kg combined mass, are travelling at 4.2 m/s. A constant force of −140 N is applied by the brakes in stopping the bike. What braking distance is needed?

5. A 712-kg car is travelling at 5.6 m/s when a force acts on it for 8.4 s, changing its velocity to 10.2 m/s.
- **a.** What is the change in kinetic energy of the car?
- **b.** How far did the car move while the force acted?
- **c.** How large is the force?

6. Five identical 0.85-kg books of 2.50-cm thickness are each laying flat on a table. Calculate the gain in potential energy of the system if they are stacked one on top of the other.

7. Each step of a ladder increases one's vertical height 40 cm. If a 90.0-kg painter climbs 8 steps of the ladder, what is the increase in potential energy?

8. A 0.25-kg ball is dropped from a height of 3.2 m and bounces to a height of 2.4 m. What is its loss in potential energy?

9. A 0.18-kg ball is placed on a compressed spring on the floor. The spring exerts an average force of 2.8 N through a distance of 15 cm as it shoots the ball upward. How high will the ball travel above the release spring?

10. A force of 14.0 N is applied to a 1.5-kg cart as it travels 2.6 m along an inclined plane. What is the angle of inclination of the plane?

11. A 15.0-kg model plane flies horizontally at a constant speed of 12.5 m/s.
- **a.** Calculate its kinetic energy.
- **b.** The plane goes into a dive and levels off 20.4 m closer to Earth. How much potential energy does it lose during the dive? Assume no additional drag.
- **c.** How much kinetic energy does the plane gain during the dive?
- **d.** What is its new kinetic energy?
- **e.** What is its new horizontal velocity?

12. A 1200-kg car starts from rest and accelerates to 72 km/h in 20.0 s. Friction exerts an average force of 450 N on the car during this time.
- **a.** What is the net work done on the car?
- **b.** How far does the car move during its acceleration?
- **c.** What is the net force exerted on the car during this time?
- **d.** What is the forward force exerted on the car as a result of the engine, power train, and wheels pushing backward on the road?

13. In an electronics factory, small cabinets slide down a 30.0° incline a distance of 16.0 m to reach the next assembly stage. The cabinets have a mass of 10.0 kg each.
- **a.** Calculate the speed each cabinet would acquire if the incline were frictionless.
- **b.** What kinetic energy would a cabinet have under such circumstances?

14. An average force of 8.2 N is used to pull a 0.40-kg rock, stretching a sling shot 43 cm. The rock is shot downward from a bridge 18 m above a stream. What will be the velocity of the rock just before it enters the water?

15. A 15-g bullet is fired horizontally into a 3.000-kg block of wood suspended by a long cord. The bullet sticks in the block. Compute the velocity of the bullet if the impact causes the block to swing 10 cm above its initial level.

Chapter 12

1. The boiling point of liquid chlorine is −34.60°C. Find this temperature in Kelvin.

2. Fluorine has a melting point of 50.28 K. Find this temperature in degrees Celsius.

3. Five kilograms of ice cubes are moved from the freezing compartment of a refrigerator into a home freezer. The refrigerator's freezing compartment is kept at −4.0°C. The home freezer is kept at −17°C. How much heat does the freezer's cooling system remove from the ice cubes?

4. How much heat must be added to 124 g of brass at 12.5°C to raise its temperature to 97.0°C?

5. 2.8×10^5 J of thermal energy are added to a sample of water and its temperature changes from 293 K to 308 K. What is the mass of the water?

6. 1420 J of thermal energy are added to a 100.0-g block of carbon at −20.0°C. What final temperature will the carbon reach?

7. A gold brick, mass 10.5 kg, requires 2.08×10^4 J of heat to change its temperature from 35.0°C to 50.0°C. What is the specific heat of gold?

8. An 8.00×10^2-g block of lead is heated in boiling water, 100.0°C, until the block's temperature is the same as the water's. The lead is then removed from the boiling water and dropped into 2.50×10^2 g of cool water at 12.2°C. After a short time, the temperature of both lead and water is 20.0°C.
- **a.** How much heat is gained by the cool water?
- **b.** On the basis of these measurements, what is the specific heat of lead?

9. 250.0 g of copper at 100.0°C are placed in a cup containing 325.0 g of water at 20.0°C. Assume no heat loss to the surroundings. What is the final temperature of the copper and water?

10. A 4.00×10^2-g sample of methanol at 30.0°C is mixed with a 2.00×10^2-g sample of water at 0.0°C. Assume no heat loss to the surroundings. What is the final temperature of the mixture?

11. How much heat is needed to change 50.0 g of water at 80.0°C to steam at 110°C?

12. The specific heat of mercury is 140 J/kg · C°. Its heat of vaporization is 3.06×10^5 J/kg. How much heat is needed to heat 1.0 kg of mercury metal from 10.0°C to its boiling point and vaporize it completely? The boiling point of mercury is 357°C.

13. 30.0 g of −3.0°C ice is placed in a cup containing 104.0 g of water at 62.0°C. All the ice melts. Find the final temperature of the mixture. Assume no heat loss to the surroundings.

14. Water flows over a falls 125.0 m high. If the potential energy of the water is all converted to thermal energy, calculate the temperature difference between the water at the top and the bottom of the falls.

15. During the game, the metabolism of basketball players often increases by as much as 30.0 W. How much perspiration must a player vaporize per hour to dissipate this extra thermal energy?

Chapter 13

1. How tall must a column of mercury, $\rho = 1.36 \times 10^4$ kg/m^3, be to exert a pressure equal to the atmosphere?

2. A dog, whose paw has an area of 12.0 cm^2, has a mass of 8.0 kg. What average pressure does the dog exert while standing?

3. A crate, whose bottom surface is 50.4 cm by 28.3 cm, exerts a pressure of 2.50×10^3 Pa on the floor. What is the mass of the crate?

▶ **4.** The dimensions of a waterbed are 2.13 m by 1.52 m by 0.38 m. If the frame has a mass of 91.0 kg and the mattress is filled with water, what pressure does the bed exert on the floor?

▶ **5.** A rectangular block of tin, $\rho = 7.29 \times 10^3$ kg/m^3, has dimensions of 5.00 cm by 8.50 cm by 2.25 cm. What pressure does it exert on a table top if it is laying on its side of
   a. greatest surface area?
   b. smallest surface area?

6. A rowboat, mass 42.0 kg, is floating on a lake.
   a. What is the size of the buoyant force?
   b. What is the volume of the submerged part of the boat?

7. A hydraulic lift has a large piston of 20.00-cm diameter and a small piston of 5.00-cm diameter. What is the mechanical advantage of the lift?

8. A lever on a hydraulic system gives a mechanical advantage of 5.00. The cross-sectional area of the small piston is 0.0400 m^2, and that of the large piston is 0.280 m^2. If a force of 25.0 N is exerted on the lever, what is the force given by the larger piston?

▶ **9.** A piece of metal weighs 75.0 N in air and 60.0 N in water. What is the density of the metal?

▶ **10.** A river barge with vertical sides is 20.0 m long and 10.0 m wide. It floats 3.00 m out of the water when empty. When loaded with coals the water is only 1.00 m from the top. What is the weight of the load of coal?

11. What is the change in the length of a 15.0-m steel rail as it is cooled from 1535°C to 20°C?

12. A concrete sidewalk section 8.000 m by 1.000 m by 0.100 m at exactly 0°C will expand to what volume at 35°C?

13. An air-filled balloon of 15.0-cm radius at 11°C is heated to 121°C. What change in volume occurs?

▶ **14.** A circular, pyrex watch glass of 10.0-cm diameter at 21°C is heated to 501°C. What change will be found in the circumference of the glass?

▶ **15.** A 200.0-cm copper wire and a 201-cm platinum wire are both at exactly 0°C. At what temperature will they both be of equal length?

Chapter 14

1. A periodic transverse wave that has a frequency of 10.0 Hz, travels along a string. The distance between a crest and either adjacent trough is 2.50 m. What is its wavelength?

2. A wave generator produces 16.0 pulses in 4.00 s.
   a. What is its period?
   b. What is its frequency?

3. A wave generator produces 22.5 pulses in 5.50 s.
   a. What is its period?
   b. What is its frequency?

4. What is the speed of a periodic wave disturbance that has a frequency of 2.50 Hz and a wavelength of 0.600 m?

5. One pulse is generated every 0.100 s in a tank of water. What is the speed of propagation of the wave if the wavelength of the surface wave is 3.30 cm?

▶ **6.** Five pulses are generated every 0.100 s in a tank of water. What is the speed of propagation of the wave if the wavelength of the surface wave is 1.20 cm?

▶ **7.** A periodic longitudinal wave that has a frequency of 20.0 Hz travels along a coil spring. If the distance between successive compressions is 0.400 m, what is the speed of the wave?

8. What is the wavelength of a water wave that has a frequency of 2.50 Hz and a speed of 4.0 m/s?

9. The speed of a transverse wave in a string is 15.0 m/s. If a source produces a disturbance that has a frequency of 5.00 Hz, what is its wavelength?

10. The speed of a transverse wave in a string is 15.0 m/s. If a source produces a disturbance that has a wavelength of 1.25 m, what is the frequency of the wave?

11. A wave has an angle of incidence of 24°. What is the angle of reflection?

Chapter 15

1. The echo of a ship's fog horn, reflected from an iceberg, is heard 5.0 s after the horn is sounded. How far away is the iceberg?

2. What is the speed of sound that has a frequency of 250 Hz and a wavelength of 0.600 m?

3. A sound wave has a frequency of 2000 Hz and travels along a steel rod. If the distance between successive compressions is 0.400 m, what is the speed of the wave?

4. What is the wavelength of a sound wave that has a frequency of 250 Hz and a speed of 400 m/s?

5. What is the wavelength of sound that has a frequency of 539.8 Hz?

6. What is the wavelength of sound that has a frequency of 320.0 Hz?

▶ **7.** A stone is dropped into a mine shaft 250.0 m deep. How many seconds pass before the stone is heard to strike the bottom of the shaft?

▶ **8.** A rifle is shot in a valley formed between two parallel mountains. The echo from one mountain is heard after 2.00 s and from the other mountain 2.00 s later. What is the width of the valley?

▶ **9.** Sam, a train engineer, blows a whistle that has a frequency of 4.0×10^2 Hz as the train approaches a station. If the speed of the train is 25 m/s, what frequency will be heard by a person at the station?

▶ **10.** Jane is on a train that is travelling at 95 km/h. The train passes a factory whose whistle is blowing at 288 Hz. What frequency does Jane hear as the train approaches the factory?

11. What is the sound level of a sound that has a sound pressure one tenth of 90 dB?

12. What is the sound level of a sound that has a sound pressure ten times 90 dB?

13. A tuning fork produces a resonance with a closed tube 19.0 cm long. What is the lowest possible frequency of the tuning fork?

14. How do the frequencies of notes that are an octave apart compare?

15. Two tuning forks of 320 Hz and 324 Hz are sounded simultaneously. What frequency of sound will the listener hear?

16. How many beats will be heard each second when a string with a frequency of 288 Hz is plucked simultaneously with another string that has a frequency of 296 Hz?

17. A tuning fork has a frequency of 440 Hz. If another tuning fork of slightly lower pitch is sounded at the same time, 5.0 beats per second are produced. What is the frequency of the second tuning fork?

Chapter 16

1. The wavelength of blue light is about 4.5×10^{-7} m. Convert this to nm.

2. As a spacecraft passes directly over Cape Kennedy, radar pulses are transmitted toward the craft and are then reflected back toward the ground. If the total time interval was 3.00×10^{-3} s, how far above the ground was the spacecraft when it passed over Cape Kennedy?

3. It takes 4.0 years for light from a star to reach Earth. How far away is this star from Earth?

4. The planet Venus is sometimes a very bright object in the night sky. Venus is 4.1×10^{10} m away from Earth when it is closest to Earth. How long would we have to wait for a radar signal to return from Venus and be detected?

5. The distance from Earth to the moon is about 3.8×10^8 m. A beam of light is sent to the moon and, after it reflects, returns to Earth. How long did it take to make the round trip?

6. A baseball fan in a ball park is 101 m away from the batter's box when the batter hits the ball. How long after the batter hits the ball does the fan see it occur?

7. A radio station on the AM band has an assigned frequency of 825 kHz (kilohertz). What is the wavelength of the station?

8. A short-wave, HAM, radio operator uses the 5-m band. On what frequency does the HAM operate?

2. Green light passes through a double slit for which $d = 0.20$ mm and it falls on a screen 2.00 m away. The first-order image is at 0.50 cm. What is the wavelength of the light?

3. Yellow light that has a wavelength of 6.00×10^2 nm passes through two narrow slits that are 0.200 mm apart. An interference pattern is produced on a screen 180 cm away. What is the location of the first-order image?

4. Violet light that has a wavelength of 4.00×10^2 nm passes through two slits that are 0.0100 cm apart. How far away must the screen be so the first-order image is at 0.300 cm?

▶ 5. Two radio transmitters are 25.0 m apart and each one sends out a radio wave with a wavelength of 10.0 m. The two radio towers act exactly like a double-slit source for light. How far from the central band is the first-order image if you are 15.0 km away? (Yes, this really happens. Radio stations can and do fade in and out as you cross the nodals and the antinodals.)

6. Monochromatic light passes through a single slit, 0.500 mm wide, and falls on a screen 1.0 m away. If the distance from the centre of the pattern to the first band is 2.6 mm, what is the wavelength of the light?

7. Red light that has a wavelength of 7.50×10^2 nm passes through a single slit that is 0.1350 mm wide. How far away from the screen must the slit be if the first dark band is 0.9000 cm away from the central bright band?

8. Microwaves with a wavelength of 3.5 cm pass through a single slit 0.85 cm wide and fall on a screen 91 cm away. What is the distance to the first-order band?

▶ 9. Radio waves that are emitted by two adjacent radio transmitters behave like light waves coming from a double slit. If two transmitters, 1500 m apart, each send out radio waves with a wavelength of 150 m, what is the diffraction angle?

10. What is the average distance between the lines of a diffraction grating if the number of lines per millimetre is 425?

11. A transmission grating with 5.85×10^3 lines/cm is illuminated by monochromatic light that has a wavelength of 492 nm. What is the diffraction angle for the first-order image?

12. Monochromatic light illuminates a transmission grating having 5900 lines/cm. The diffraction angle for a first-order image is 18.0°. What is the wavelength of the light in nanometres?

13. A transmission grating, 5.80×10^3 lines/cm, is illuminated by a monochromatic light source that has a wavelength of 495 nm. How far from the centre line is the first-order image if the distance to the grating is 1.25 m?

14. A pinhole camera uses a 1.5-mm hole instead of a lens to form an image. What is the resolution of this camera for green light, 545-nm wavelength, if the film is 6.0 cm behind the pinhole?

Chapter 20

1. Two charges, q_1 and q_2, are separated by a distance, d, and exert a force on each other. What new force will exist if d is doubled?

2. Two charges, q_1 and q_2, are separated by a distance, d, and exert a force on each other. What new force will exist if q_1 and q_2 are both doubled?

3. Two identical point charges are separated by a distance of 3.0 cm and they repel each other with a force of 4.0×10^{-5} N. What is the new force if the distance between the point charges is doubled?

▶ 4. An electric force of 2.5×10^{-4} N acts between two small equally-charged spheres which are 2.0 cm apart. Calculate the force acting between the spheres if the charge on one of the spheres is doubled and the spheres move to a 5.0-cm separation.

5. How many electrons would be required to have a total charge of 1.00 C on a sphere?

6. If two identical charges, 1.000 C each, are separated by a distance of 1.00 km, what is the force between them?

7. Two point charges are separated by 10.0 cm. If one charge is $+20.00$ μC and the other is -6.00 μC, what is the force between them?

8. The two point charges in the previous problem are allowed to touch each other and are again separated by 10.00 cm. Now what is the force between them?

9. Determine the electrostatic force of attraction between a proton and an electron that are separated by 5.00×10^2 nm.

10. Find the force between two charged spheres 1.25 cm apart if the charge on one sphere is 2.50 μC and the charge on the other sphere is 1.75×10^{-8} C.

11. Two identical point charges are 3.00 cm apart. Find the charge on each of them if the force of repulsion is 4.00×10^{-7} N.

12. A charge of 4.0×10^{-5} C is attracted by a second charge with a force of 350 N when the separation is 10.0 cm. Calculate the size of the second charge.

▶ 13. Three particles are placed on a straight line. The left particle has a charge of $+4.6 \times 10^{-6}$ C, the middle particle has a charge of -2.3×10^{-6} C, and the right particle has a charge of -2.3×10^{-6} C. The left particle is 12 cm from the middle particle and the right particle is 24 cm from the middle particle. Find the total force on the middle particle.

▶ 14. The left particle in the problem above is moved directly above the middle particle, still 12 cm away. Find the force on the middle particle.

Chapter 21

1. How strong would an electric field have to be to produce a force of 1.00 N if the charge was 1.000×10^3 μC?

2. A positive charge of 7.0 mC experiences a 5.6×10^{-2}-N force when placed in an electric field. What is the size of the electric field intensity?

3. A positive test charge of 6.5×10^{-6} C experiences a force of 4.5×10^{-5} N. What is the magnitude of the electric field intensity?

4. A charge experiences a force of 3.0×10^{-3} N in an electric field of intensity 2.0 N/C. What is the magnitude of the charge?

5. What is the size of the force on an electron when the electron is in a uniform electric field that has an intensity of 1.000×10^3 N/C?

6. Sketch the electric field lines around a -1.0-μC charge.

7. It takes 8.00 mJ to move a charge of 4.00 μC from point **A** to point **C** in an electric field. What is the potential difference between the two points?

8. How much work is required to move a positive charge of 2.5 μC between two points that have a potential difference of 60 V?

▶ 9. A cloud has a potential difference relative to a tree of 9.00×10^2 MV. During a lighting storm, a charge of 1.00×10^2 C travels through this potential difference. How much work is done on this charge?

10. A constant electric field of 750 N/C is between a set of parallel plates. What is the potential difference between the parallel plates if they are 1.5 cm apart?

11. A spark will jump between two people if the electric field exceeds 4.0×10^6 V/m. You shuffle across a rug and a spark jumps when you put your finger 0.15 cm from another person's arm. Calculate the potential difference between your body and the other person's arm.

12. A potential difference of 0.90 V exists from one side to the other side of a cell membrane that is 5.0 nm thick. What is the electric field across the membrane?

▶ 13. An oil drop having a charge of 8.0×10^{-19} C is suspended between two charged parallel plates. The plates are separated by a distance of 8.0 mm, and there is a potential difference of 1200 V between the plates. What is the weight of the suspended oil drop?

14. A capacitor accumulates 4.0 μC on each plate when the potential difference between the plates is 100 V. What is the capacitance of the capacitor?

15. What is the voltage across a capacitor with a charge of 6.0 μC and a capacitance 7.0 pF?

16. How large is the charge accumulated on one of the plates of a 30-μF capacitor when the potential difference between the plates is 120 V?

Chapter 22

1. How many amperes of current flow in a wire through which 1.00×10^{18} electrons pass per second?

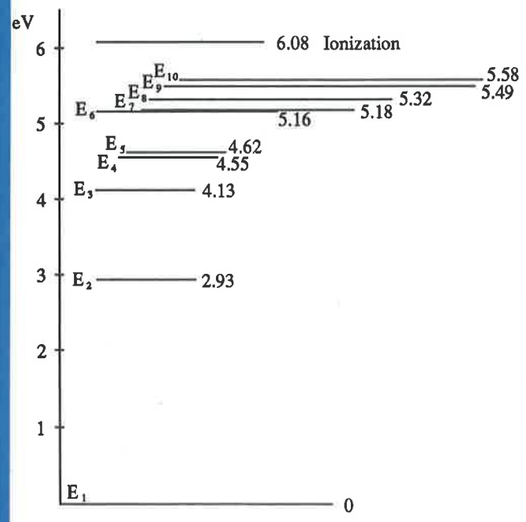
12. What velocity would an electron need to have a wavelength of 3.0×10^{-10} m associated with it?

13. An electron is accelerated across a potential difference of 5.0×10^3 V in the CRT of a television.
- **a.** What is the velocity of the electron if it started from rest?
- **b.** What is the wavelength associated with the electron?

Chapter 28

1 A calcium atom drops from 5.16 eV above the ground state to 2.93 eV above the ground state. What is the frequency of the photon emitted by the atom?

2. A calcium atom is in an excited state when the energy level is 2.93 eV, E_2, above the ground state. A photon of energy 1.20 eV strikes the calcium atom and is absorbed by it. To what energy level is the calcium atom raised? Refer to diagram below.



Energy Level Diagram for Calcium Atom

3. A calcium atom is in an excited state at the E_6 energy level. How much energy is released when the atom dropped down to the E_2 energy level?

4. A photon of orange light, wavelength of 600 nm, enters a calcium atom in the E_6 excited state and ionizes the atom. What kinetic energy will the electron have as it is ejected from the atom?

5. Calculate the radius of the orbital associated with the energy level E_4 of the hydrogen atom.

6. Calculate the energy associated with the E_7 and the E_2 energy levels of the hydrogen atom.

7. Calculate the difference in energy levels in the previous problems.

8. What frequency photon is emitted from the hydrogen atom when the atom releases the energy found in the previous problem?

Chapter 29

1. An LED, light-emitting diode, produces infrared radiation wavelength, 800 nm, when an electron jumps from the conduction band to the valence band. Find the energy width of the forbidden gap in this diode.

2. How many free electrons exist in 1.00 cm^3 of lithium? Its density is 0.534 gm/cm^3, atomic mass is 6.941 g/mol, and there is one free electron per atom.

3. The voltage drop across a diode is 0.70 V when it is connected in series to a 210-Ω resistor and a battery, and there is a 11-mA current. If the LED has an equivalent resistance of 70 Ω, what potential difference must be supplied by the battery?

4. What resistor would replace the 210-Ω resistor in the previous problem if the current was changed to 30 mA?

5. What would the new current in the previous problem be if the leads on the battery were reversed?

Chapter 30

1. What particles, and how many of each, make up an atom of $^{109}_{47}Ag$?

2. A calcium ion has 20 protons and 20 neutrons. Write its isotopic symbol.

3. What is the isotopic symbol of a zinc atom composed of 30 protons and 34 neutrons?

4. Write the complete nuclear equation for the alpha decay of $^{210}_{84}Po$.

5. Write the complete nuclear equation for the beta decay of $^{14}_{6}C$.

6. Complete the nuclear reaction:
$^{225}_{89}Ac \rightarrow {}^{4}_{2}He +$

7. Complete the nuclear reaction:
$^{227}_{88}Ra \rightarrow {}^{0}_{-1}e +$

8. Complete the nuclear reaction:
$^{65}_{29}Cu + {}^{1}_{0}n \rightarrow \_\_\_\_ \rightarrow {}^{1}_{1}p +$

9. Complete the nuclear equation:
$^{235}_{92}U + {}^{1}_{0}n \rightarrow {}^{96}_{40}Zr + 3({}^{1}_{0}n) +$

10. An isotope has a half-life of 3.0 d. What percent of the original material will be left after
- **a.** 6.0 d?
- **b.** 9.0 d?
- **c.** 12 d?

11. $^{211}_{86}Rn$ has a half-life of 15 h. What fraction of a sample would be left after 60 h?

12. $^{209}_{84}Po$ has a half-life of 103 years. How long would it take for a 100-g sample to decay so only 3.1 g of Po-209 was left?

13. The positron, $^{0}_{+1}e$, is the antiparticle to the electron and is the particle ejected from the nucleus in some nuclear reactions. Complete the nuclear reaction:
$^{17}_{9}F \rightarrow {}^{0}_{+1}e +$

14. Complete the nuclear reaction: $^{22}_{11}Na \rightarrow {}^{0}_{+1}e +$

15. Find the charge of a π^+ meson made of a *u* and *anti-d* quark pair.

16. Baryons are particles that are made of three quarks. Find the charge on each of the following baryons.
- **a.** neutron; *d, d, u* quark triplet
- **b.** antiproton; *anti-u, anti-u, anti-d* quark triplet

Chapter 31

1. The carbon isotope, $^{12}_{6}C$, has a nuclear mass of 12.000 000 u.
- **a.** What is the mass defect of this isotope?
- **b.** What is the binding energy of its nucleus?

2. The sulphur isotope, $^{32}_{16}S$, has a nuclear mass of 31.972 07 u.
- **a.** What is the mass defect of this isotope?
- **b.** What is the binding energy of its nucleus?

3. The sodium isotope, $^{22}_{11}Na$, has a nuclear mass of 21.994 434 u.
- **a.** What is the mass defect of this isotope?
- **b.** What is the binding energy of its nucleus?
- **c.** What is the binding energy per nucleon?

4. The binding energy for $^{7}_{3}Li$ is 39.25 MeV. Calculate the mass of the lithium-7 nucleus in atomic mass units.

5. Write the complete nuclear equation for the positron decay of $^{132}_{55}Cs$.

6. Complete the nuclear reaction:
$^{14}_{7}N + {}^{1}_{0}n \rightarrow \_\_\_\_ \rightarrow {}^{1}_{1}p +$

7. Complete the nuclear reaction:
$^{65}_{29}Cu + {}^{1}_{0}n \rightarrow \_\_\_\_ \rightarrow {}^{1}_{1}p +$

8. When a magnesium isotope, $^{24}_{12}Mg$, is bombarded with neutrons, it absorbs a neutron and then emits a proton. Write the complete nuclear equation for this reaction.

9. When oxygen-17 is bombarded by neutrons, it absorbs a neutron and then emits an alpha particle. The resulting nucleus is unstable and it will emit a beta particle. Write the complete nuclear equation for this reaction.

10. Complete the following fission reaction:
$^{239}_{94}Pu + {}^{1}_{0}n \rightarrow {}^{137}_{52}Te + 3({}^{1}_{0}n)$

11. Complete the following fission reaction:
$^{233}_{92}U + {}^{1}_{0}n \rightarrow {}^{134}_{55}Cs + 2({}^{1}_{0}n) +$

12. Complete the following fission reaction:
$^{235}_{92}U + {}^{1}_{0}n \rightarrow {}^{90}_{38}Sr + 10({}^{1}_{0}n) +$

13. Strontium-90 has a mass of 89.907 747 u, xenon-136 has a mass of 135.907 221 u, and uranium-235 has a mass of 235.043 915 u.
- **a.** Compute the mass defect in the previous problem.
- **b.** Compute the amount of energy released.

14. One of the simplest fusion reactions involves the production of deuterium, $^{2}_{1}H$ (2.014 102 u), from a neutron and a proton. Write the complete fusion reaction and find the amount of energy released.

15. The fusion reactions most likely to succeed in a fusion reactor are listed below. Complete each fusion reaction.
- **a.** $^{2}_{1}H + {}^{2}_{1}H \rightarrow {}^{3}_{1}H +$
- **b.** $^{2}_{1}H + {}^{2}_{1}H \rightarrow {}^{3}_{2}He +$
- **c.** $^{2}_{1}H + {}^{3}_{1}H \rightarrow {}^{4}_{2}He +$
- **d.** $^{3}_{1}H + {}^{3}_{1}H \rightarrow {}^{4}_{2}He + 2$